A NEW GENUS BASED ON THE SEVEN-BANDED *RICHARDSONIANUS DAWBINI* RICHARDSON 1969 (HIRUDINOIDEA: RICHARDSONIANIDAE)[1]

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Synopsis

The new genus has the vaginal duct proportionally longer than in the g. *Bassianobdella*. Hibernation is recorded, as also predation on *Goddardobdella elegans* with evidence for predation on other invertebrates. Mass aggregation of *G. elegans* is described.

The type species for the new genus is an aquatic jawed sanguivore, the median regions of the reproductive systems formed each on a posteriorly directed primary loop, bimyomeric and mesomorphic; the vagina with a relatively long vaginal duct; etc.; the general morphology of the median regions resembling those in *Richardsonianus australis*. Essentially on this basis, *dawbini* was assigned to the g. *Richardsonianus* and recognized from the pattern as a new species (Richardson, 1969*a*). The vagina in *dawbini* is U-shaped with subequal limbs, and this was interpreted at that time as an immature form similar to the folded immature vagina known to me in *Hirudo medicinalis* and *Goddardobdella elegans*, both of which lack a vaginal duct.

Subsequently (Richardson, 1970), a U-shaped vagina was found in a 7-banded leech from Victoria. This species has a very short, atypical vaginal duct, leading me to recognize the U-shaped vagina as developed on the posterior portions and around the elbow of the primary loop, and as such, a distinctive morphological form which is associated in 7-banded leeches with elongate cylindrical ejaculatory bulbs, a combination not seen in other leeches. The g. *Bassianobdella* was provided for 7-banded leeches with the short atypical vaginal duct, and individual species have now been described from Victoria (Richardson, 1970), Tasmania (1971), New South Wales (1972*a*), and a possible fourth, undescribed, species for Kangaroo Island, South Australia. It was indicated (1970) that a separate and new genus was required for 7-banded leeches of the Torresian.

It seemed possible (1970) that the combination of elongate cylindrical ejaculatory bulbs and a U-shaped vagina might lead to a division of the Richardsonianidae into subfamilies. This has become doubtful. Elongate cylindrical ejaculatory bulbs are now known in *Quantenobdella howensis* of Lord Howe Island (Richardson, 1972*b*) and *Habeobdella stagni* of south-western Western Australia (1972*c*), both of these having a typical long vaginal duct, the vagina restricted to the posterior portion of the recurrent limb of the primary loop, and a 5-banded pattern.

Hirudo novemstriata Grube 1867 is based on specimens from Rockhampton, Queensland, and known only in Grube's accounts. It is described as having nine longitudinal dorsal dark bands, the median wider than the paired bands which are narrow and of equal width; the bands separated by eight narrow light stripes; the stripes commencing at the 10th annulus, etc. (Richardson, 1969*b*). In preserved specimens of *dawbini*, the marginal light stripes show in dorsal view, these with the three pairs of narrow stripes give a total of eight stripes; the wide band of the paramedian fields, diminish so that the medial half is paler than

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the lateral half, and the two appear each as a dark band, narrow, and of the width of the other paired bands, giving eight narrow bands and a wider median band, a total of nine. Grube describes the margins as continuous with the venter, the paired stripes commencing in somite viii. On these two points, *novemstriata* differs from *dawbini*, otherwise it seems most probable that *novemstriata* is a 7-banded leech.

Dr. A. Soos, the Hungarian Museum of Natural History, has examined the Grube collection, now housed in the Zoologische Museum, Humboldt-Universitat zu Berlin. He informs me there are no specimens in the collection labelled as *Hirudo novemstriata*.

Kaiyabdella gen. nov.

Derivation: Kaiya (Aborigine), to bite ; bdella, a leech. f.

Richardsonianidae ; ix to xxiv complete 5-annulate (total 16) ; xxv, 4-annulate ; somital sense organs, small ; jaws, small, located in open recesses ; teeth, about 50, small, narrowly spaced ; no salivary gland papillae ; dorsal salivary glands, sparse, with poorly formed right and left columns of aggregated ducts ; radial muscles, an obvious system ; mouth and lumen of pharynx, narrow, the lumen tapering ; pharynx with six internal muscular ridges as a dorsolateral and ventrolateral pairs, each pair joining to enter a jaw, none ending independently on the margin of the entrance to the pharynx ; pharynx terminating anteriorly in ix, with the compartments in xi to xviii each with a pair of small lobed secondary anterior caeca and a larger pair of simple primary caeca at the median level, the latter increasing in size posteriorly and from xv extending into the following somite ; xix, postcaeca originate from the anterior level in the somite and extend to xxv/xxvi ; the compartment in xix reduced in diameter behind the postcaeca, narrowly tubular to xix/xx and joining terminally to the intestine ; intestine, tubular, tapering posteriorly to join terminally to the rectum ; genital pores, xi b_5/b_6 and xii b_5/b_6 ; 10 pairs of simple saccular testes ; anterior regions of paired male ducts with the epididymis in the adjacent halves of xii and xiii, posterior to the elongate cylindrical ejaculatory bulbs in the adjacent halves of xi and xii ; median regions, bimyomeric, mesomorphic ; penis sheath, reflecting in xii b_2 ; oviducts, very short ; common oviduct, long ; vagina caecate, cylindrical, folded on itself at xiii/xiv or in xiv as subequal recurrent and procurrent limbs ; vaginal duct longer than the procurrent limb of the vagina ; vagina and duct, ventral to the crop. Pattern, striped. Aquatic. Sanguivorous. Australian region.

Type species: *Richardsonianus dawbini* Richardson 1969 (Richardson, 1969*a*, p. 128).

The following description is based on specimens from Alumy Creek, Grafton, N.S.W., the type locality, and others from waters on the Clarence River flood plain.

General Form

In life, a strongly muscular leech of moderate size, capable of moderate extension. At rest, elongate, tapering subcylindrical anteriorly, somewhat depressed posteriorly with obtusely rounded margins ; the posterior sucker, large, and only slightly less than the maximum width of the body. Extended, subcylindrical. An elegant capable swimmer, the posterior two-thirds of the body flattened, the margins not sharply keeled posteriorly.

Preserved, extended, anteriorly subcylindrical, gradually widening from the small anterior sucker to be slightly depressed along the nephric region, narrowing obtusely in the postnephric region to form a wide base for the posterior sucker.

In life, a specimen 35·0 mm. long at rest, was 12·0 mm. long in maximum contraction ; 45·0 mm. in full extension.

Preserved, extended specimens taken in December, range in length from 45·0 mm. to 82·0 mm. In a specimen 50·0 mm. long, the anterior sucker is 2·0 mm. wide ; the width at v/vi, 2·5 mm., increasing behind this to 3·75 mm. at 10·0 mm. from the anterior end, with a depth of 1·75 mm. ; the width increasing gradually posteriorly to a maximum of 4·0 mm. at xxii (50·0mm.from the anterior end) and the depth, 2·0 mm. along this region ; narrowing behind xxv to the basis (2·0 mm. wide) of the posterior sucker which is a little wider (3·75 mm.) than long, and has about 32 muscular rays on the ventral surface.

Colour

In life, generally brownish, dark brown to greyish brown, with a black median band, and three pairs of dark brown bands ; the bands separated by narrow golden to golden yellow contrast stripes ; a dusky yellow marginal stripe separates the dorsum from the dusky greenish yellow to ashen grey venter which is irregularly maculate with dark black to greyish black patches. The dorsum of the posterior sucker, uniformly dark brown excepting the pale margin.

Preserved, the general colour diminishes to a pale greyish brown ; the median band, to dark greyish black ; the paired bands, to be greyish, excepting the lateral half of the inner paired bands is distinctly darker than the medial half ; the stripes, to pale cream or dusky white ; the venter, dark grey.

Pattern. Fig. 1, A, B, F

The median band is continuous, excepting in an occasional specimen in which it may be interrupted at intervals for a length of about an annulus. The median band varies slightly in width. In the majority, it fills the median field and extends to include the line of paramedian somital sense organs which may be within the band, in contact with the margin of the band, or immediately lateral to the margin of the band and in the inner paired stripe, recognizably closer to the medial edge of the stripe.

The narrow inner and middle paired stripes occupy the medial and lateral portions of the paramedian fields which are completed by the wide inner paired bands.

The narrow middle and outer paired bands extend along the lines of the intermediate and supramarginal sense organs, very briefly into the adjacent fields, and are separated by the narrow outer paired stripe of the intermediate fields.

The marginal stripes include the marginal sense organs, occupy the marginal field (supramarginal+submarginal), extend from xxvi a_1a_2/a_3 anteriorly to form a narrow contrast edge on the velum and this includes the preocular paramedians of somite i.

The ocular arch is entirely within the background colour which is complete between the margins across ii and iii, and complete across xxvii.

The narrow inner paired stripes of the paramedian fields extend from iii/iv to xxvi/xxvii and are continuous ; the narrow middle paired stripes, lateral in the paramedian field, extends from just in v or v/vi to xxv/xxvi, and may be either continuous or broken briefly anteriorly for about the length of an annulus ; the two stripes totalling less than half of the width of the field which is completed by the wide inner paired band defined between them, the width of this band increasing as the body widens so that it occupies always the greater part of the field, and is the widest band.

The outer paired stripes occupy the greater part of the intermediate fields, are continuous from vi a_2/a_3 to xxv/xxvi, or just into xxvi, and divide the middle and outer paired bands between these limits.

The venter is dark, paler than the dorsum, sharply separated from the marginal stripes ; maculate, the maculae of the length of an annulus or shorter,

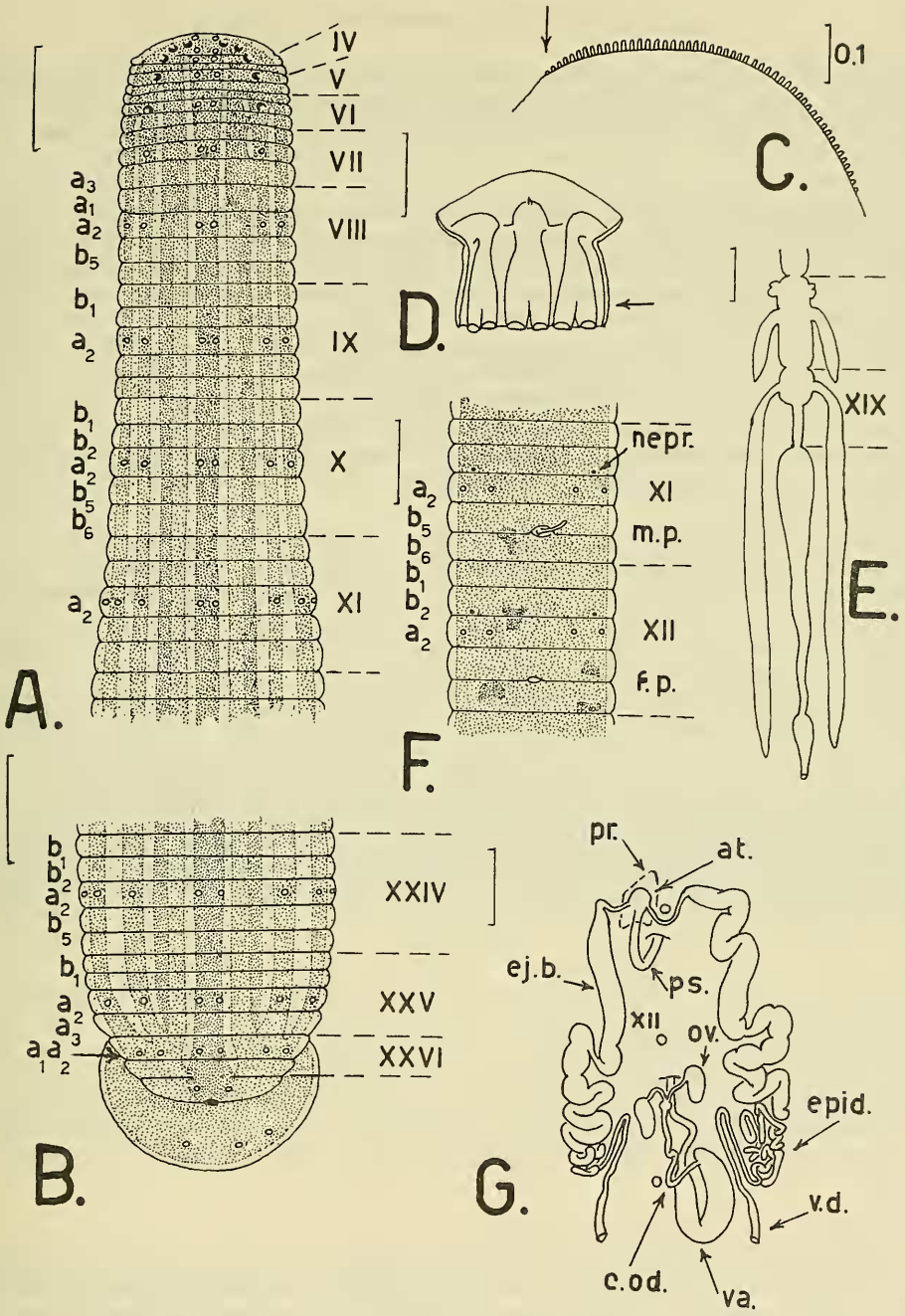

Fig. 1. *Kaiyabdella dawbini* (Richardson 1969). A. Dorsal aspect, somites i to xi, and B. xxiv to xxvii, showing annulation and pattern. C. Right ventrolateral jaw and dentition, arrow indicates medial end. D. Pharynx opened along mid-ventral line to show internal muscular ridges ; jaws ; arrow indicates mid-point in the length of the pharynx. E. Compartments and caecation of crop in xviii and xix, postcaeca ; intestine. F. Ventral aspect, somites xi and xii ; pattern ; genital pores, etc. G. Anterior region of male paired ducts ; male median region ; and female reproductive system, the female median region displaced so that the dorsal aspect of the vagina is at the right.

Somites and somital ganglia indicated by Roman figures ; intersomital levels, by broken lines ; annuli, " a_2 ", etc. ; somital ganglia shown at relative size.

at., atrium ; c.od., common oviduct ; ej.b., ejaculatory bulb ; epid., epididymis ; f.p., female pore ; m.p., male pore ; nepr., nephropore ; ov., ovary ; pr., prostate ; ps., penis sheath ; va., vagina ; v.d., vas deferens.

Scales, 2·0 mm, excepting C., 0·1 mm.

irregular in form, often squarish to rectangular, varying from one to three to five in a somite, few in the pregenital region, increasingly more numerous posteriorly, with the venter closely maculated from xx to xxv.

Annulation. Fig. 1, A, B, F

Somital sense organs obvious in small round white patches on the dorsum and venter as transverse and longitudinal series, only marginals detectable with difficulty. Secondary sensillae obvious as white points, one or two in the median field, four or five in each paramedian field, one or two in each intermediate field, back to vii/viii, and behind this many annuli carry a very fine transverse white line in place of individual spaced sensillae. Nephropores, obvious, each in a small white patch, elevated on low papillae in some specimens, and situated just medial to the line of the ventral intermediate sense organs. Intersomital and interannular furrows, equivalent, no general indication of couplets or triplets of annuli, nor of somital limits as such. Annuli in moderately extended specimens often divided into narrow longitudinal rectangles by fine lines, but nowhere morphologically areolate.

Somite i is indicated by a pair of distinct well-formed paramedian sense organs immediately anterior to the first pair of eyes in the paramedian line in ii; somite iii carries the second pair of eyes and a distinct pair of paramedian sense organs; iii/iv, extending across the median and paramedian fields, incompletely separates iii from iv, but is indicated by a short length on the margin which defines the anterior edge of the dorsolateral lobe of the sucker; somite iv, incomplete 2-annulate, a_1a_2 with the third pair of eyes and obvious paramedians $>a_3$, a_1a_2/a_3 sometimes weak in the intermediate field, incises the dorsolateral lobe of the margin of the sucker, and this lobe strongly defined posteriorly by iv/v; v, 2-annulate above, a_1a_2 with the fourth eyes $=a_3$, a_1a_2/a_3 reaches to the marginal sense organs so that a_1a_2 forms the upper portion of the lateral margin of the sucker and uniannulate v completes this and the ventral margin; vi, 3-annulate above, $a_1<a_2<a_3$, the fifth pair of eyes small and often obscure in a_2, the furrow a_1/a_2 reaching to the submarginals and vi 2-annulate below this with $a_1a_2>a_3$; vii, 3-annulate above and below, $a_1<a_2<a_3$; vii a_3=viii a_1; viii, 4-annulate, $a_1>a_2=b_5>b_6$, the first pair of nephropores on a_1; ix to xxiv, 5-annulate (total 16); ix, $b_1<b_2<a_2>b_5<b_6$; x, $b_1<b_2=a_2=b_5>b_6$; xi, $b_1<b_2=a_2<b_5>b_6$; xii, $b_1=b_2<a_2=b_5=b_6$; xiii to xxii, with the annuli closely equal, $b_1=b_2=a_2=b_5=b_6$; xxiii, $b_1=b_2<a_2>b_5=b_6$, as also xxiv but with $b_5>b_6$, the last nephropores on xxiv b_2; xxv, 4-annulate $b_1=b_2<a_2<a_3$, and xxv a_3 the last annulus complete across the venter; xxvi, 2-annulate, $a_1a_2>a_3$, the somital sense organs posterior in a_1a_2; the furrow xxvi/xxvii, incomplete in the median field; xxvii, uniannulate, with the anus at the posterior margin.

Some paramedians and intermediates show on the dorsum of the posterior sucker.

Alimentary Tract. Fig. 1, C, D, E

The jaws are housed in open recesses; small, low convex in profile and about 0·5 mm. high at the median end; the dental margin, low convex, about 0·6 mm. long; teeth, about 50, narrowly conical, tapering to a point, narrowly spaced, minute, the tallest near the medial end, about 0·02 mm. high, and the height diminishing very gradually along the row.

There are no salivary gland papillae.

The entrance to the pharynx is small, no wider than the base of the dorsomedian jaw; pharynx, suspended by an obvious system of extrinsic radial muscles extending back into x; pharynx, rather thin-walled, the lumen restricted, tapering; three pairs of internal muscular ridges, dorsomedian and ventrolaterals, each pair fusing at about the middle of the length of the pharynx into

a single ridge which enters the appropriate jaw ; no ridges ending independently on the margin of the entrance to the pharynx.

Salivary glands, relatively sparse ; the dorsal glands not divided obviously into compact masses, the ducts partially aggregated but not forming strongly developed columns.

The pharynx terminates in the middle of ix, followed by a short simple compartment ; in x, a full compartment of the crop with a pair of small, simple caeca in the anterior position ; in xi, and posteriorly, secondary small simple anterior caeca (lacking in some specimens) and simple longer primary caeca in the median position which are increasingly longer from xiii extending posteriorly in the paramedian chamber into the anterior portion of the following somite ; nowhere an indication of secondary posterior caeca. In xix, the postcaeca emerge from the lateral aspects of the anterior portion of the compartment and extend into xxv ; the posterior portion of the compartment in xix reduced abruptly behind the postcaeca to be narrowly tubular, thin-walled, and connects terminally to the intestine at xix/xx, opening through a small internal papilla which includes a sphincter.

The intestine, broadly tubular initially, lacking compartmentation, tapers progressively to join terminally to the rectum at xxiii/xxiv ; rectum, wider than the terminal portion of the intestine, tapers to end at the anus.

Reproductive System. Fig. 1, F, G

Epididymis posterior to the ejaculatory bulb, the relationship, linear ; ejaculatory bulbs, elongate, cylindrical ; median regions, bimyomeric, mesomorphic, formed on posteriorly directed primary loops ; vagina, caecate, U-shape with subequal limbs, and a long vaginal duct.

Genital pores, xi b_5/b_6 and xii b_5/b_6.

Testes, 10 pairs in the median longitudinal chamber, the first at xiii/xiv, the last at xxii/xxiii, saccular, each connecting by a short vas efferens to the vasa deferentia in the paramedian chambers ; growth of the epididymis posteriorly in the anterior half of xiii results in a reflection of the vas deferens posteriorly from xii/xiii into the anterior half of xiii as a simple secondary loop ; epididymis, a closely coiling single mass in the contiguous halves of xii and xiii, continuing anteriorly from this as a wider thin-walled tubular portion with much of the appearance of a sperm duct and folded on itself in an S-form in the posterior half of xii ; this portion reduces abruptly into a very narrowly tubular connection to the ventral end of the ejaculatory bulb at or posterior to the level of ganglion xii ; ejaculatory bulb muscular, tubular, elongate, of the length of a somite, almost straight or folded vertically on itself, reducing abruptly to continue as the narrow, muscular, short, ejaculatory ducts which extend ventrally and then medially to the atrium.

The male atrium lies just anterior to ganglion xi ; the muscular, opalescent penis sheath, elongated in a primary loop reflecting at xi/xii ; the recurrent limb longer than the procurrent limb.

Ovaries, simple saccular, small, located in the posterior half of xii, briefly posterior to the anterior end of the vaginal duct ; oviducts, short, each no longer than an ovary, join at xii/xiii into a distinct atrium.

Female median region formed in the median chamber on a posteriorly directed primary loop reflecting at xiii/xiv ; common oviduct, thin-walled with a relatively large lumen, elongate, occupies the anterior portion of the recurrent limb, the vaginal duct the equivalent portion of the procurrent limb, the two of a similar length and intimately associated along the length of the vaginal duct, the common oviduct departing the vaginal duct to loop anteriorly briefly in a secondary loop to join subterminally to the vagina ; vaginal caecum, short,

small ; vagina U-shape, extending as a single continuous chamber along the posterior portion of the recurrent limb, around the elbow, and along the posterior portion of the procurrent limb, of the primary loop, and tapering briefly in joining the vaginal duct ; vaginal duct, strongly muscular with a reduced lumen, loosely folded on itself or tortuous, but always distinctly longer than either limb of the vagina ; vagina and duct always ventral to the crop.

Prostate glands, an elongate pyriform compact mass enclosing the atrium (partially in some), and tapering briefly along the penis sheath ; albumin glands, thick, uniform ensheathment of the full length of the common oviduct.

General Behaviour, Distribution, etc.

Kaiyabdella dawbini is a firm-bodied muscular leech which readily escapes between the fingers of the tightly clenched hand. It is an elegant swimmer, occasionally to be seen swimming quite slowly close to the bottom, and capable of swimming short distances, 5 to 10 feet at a relatively fast speed—in the order of a foot a second. Generally, it is secretive, to be found beneath logs and stones, hidden in crevices and in the submerged axils of bulrush, etc., and must be searched for.

It is known from the coastal flood-plain of the Clarence River and adjacent systems in north-eastern New South Wales. I have not found it on the plateau or tablelands. It occurs in lowland streams, ponds, long-established dams, mostly small waters with a soft river silt bottom, rich with and even choked by submerged and emergent aquatic vegetation ; but it is also present in Lakes Hiawatha and Minnie Water, both small shallow lakes inside the coastal dunes, firm bottomed, with only a sparse spaced emergent vegetation.

Out of water, placed on its back on a firm surface, *dawbini* does not right itself in the usual manner, a torsion of the anterior end of the body, attachment of the anterior sucker, and the body then rolled over progressively from the anterior end until righted ; but flexes the body ventrally, raising both ends. It then flexes the body dorsally, arching it on the surface, and by rapid repetition of these two actions, suddenly rights the body.

K. dawbini is commonly associated with *Goddardobdella elegans*, with the latter as the more abundant species, e.g. 40 *dawbini* and 154 *elegans* in a collection made on two days at Alumy Creek, Grafton, N.S.W. This is paralleled in my experience of *Bassianobdella fusca*. A thorough search of 300 yards along a tributary of the Macquarie yielded two specimens of *fusca* and six specimens of *Richardsonianus* sp., with the latter a readily collected species elsewhere in this system (Richardson, 1972*a*).

Both *dawbini* and *elegans* are essentially secretive, with *elegans* the more rapidly reactive sanguivore. When the collector enters a water, *elegans* will appear within five minutes ; *dawbini*, rarely in less than 10 minutes and most commonly long after all *elegans* in the vicinity have been collected. *B. fusca* did not appear until after all four *R.* sp. in the pool had been taken. Bosisto (1859) may possibly have experienced a similar slower response from *B. victoriae* than the rapidly aggressive attack of *R. australis*, paralleling the long-known difference in behaviour in the case of the monostichodont true horse-leech of Europe and the medicinal leech, and on this basis referred to *B. victoriae* as a horse-leech.

K. dawbini has not been recorded in the field from late May through to September, with one exception. Two fully grown individuals were found in mid-August, 1970, deep in a crevice in a short reef of soft rock in shallow water at Lake Hiawatha. With them, also small glossiphoniform leeches. All were lethargic. None reacted to handling. None made any attempt to escape in the water. The *dawbini* were quiescent in the hand. They appeared dormant and hibernating. These leeches were taken in the late afternoon. With full sun all day, the temperature of the waters in the shallows was 18·5° C.

Predation by K. dawbini. Fig. 2

Macrophagous erpobdellid and haemopid leeches are known predators which attack and ingest other leeches. Predation of sanguivores on other leeches is only briefly reported in the literature so far as I have seen.

Pinto (1923) refers to *Limnobdella* (now *Oxyptychus*) *brasiliensis* as cannibalistic, and as sucking blood from the crop of other leeches. Blair (1927) in an account of *Hirudo medicinalis* in England, states that he has " one actual instance of a leech fullfed, being bitten by another ". Keegan *et al.* (1969) refer to " *Hirudo* " *nipponia* as eventually killing leeches of other speeches, as attacking engorged individuals of its own species, and show (Fig. 19) many *nipponia*, a small species, attached to a large sanguivore, *Hirudinaria manillensis*.

Fig. 2. The 7-banded *Kaiyabdella dawbini* (Richardson 1969) attached to *Goddardobdella elegans* (Grube 1867) in the typical feeding posture which can be maintained for up to twelve hours.

Kaiyabdella dawbini takes vertebrate blood meals. It attacks unfed individuals of the aquatic jawed sanguivore *Goddardobdella elegans*, and takes a meal from these. In a jar, *dawbini* readily attaches to an earthworm, to a large grass grub, and remains attached for periods up to twelve hours. The crops of engorged *dawbini* taken at Lake Hiawatha contained a transparent clear, faintly bluish tinged, soft gel in which there were a few minute white bodies, each with many short coarse radiating spine-like processes, and more sparsely, a few small brownish oil globules. Colour, etc., were suggestive of crustacean haemolymph concentrated by water extraction.

The indications are that *dawbini* attacks and feeds from other suitable invertebrates, in addition to attacking vertebrates.

A collection from Alumy Creek, Grafton, on 14th November, 1967, included 36 *K. dawbini* and 131 *G. elegans* which were all placed in a large jar with water. When seen about an hour later, many of the leeches were on the sides of the jar above the water level. These were all *elegans*. Leeches in the water were swimming rapidly and erratically, with some as pairs on the bottom or sides of the jar appearing to be in copula. The pairs were recognized as a *K. dawbini* with a *G. elegans*, both with the posterior sucker attached to the glass, the *dawbini* partly folded across the *elegans*, extended along its side, and attached by the anterior sucker to the venter of the *elegans* just anterior to the level of the clitellum.

G. elegans removed from the jar were found to have from one to 20 and more wounds, some trifid as typical of the jawed sanguivorous incision, others as round holes each about 1·5 mm. in diameter, both types extending through the body wall. Such wounds were on all parts of the body, even on the margin and interior of the anterior sucker, but none on the posterior sucker. In some cases, fragments of botryoidal tissue, portions of a lateral longitudinal vessel, of epididymis, etc. protruded through the wound ; but none were seen as though cut into or perforated.

Five *G. elegans* were placed in water in a jar. When these had become quiet and settled on the glass, two *K. dawbini* were introduced into the water. Without contact with the *dawbini* or other obvious reason for reaction, the *elegans* began moving quickly and then swimming rapidly and erratically, with one moving up above the water level. The *dawbini* pursued the swimming *elegans*, soon attaching each by its anterior sucker to an *elegans*, trailing briefly with it, and the *elegans* ceasing to swim, the pair sank to the bottom of the jar.

Both attach the posterior sucker to the jar, the *dawbini* attaching and re-attaching its posterior sucker until this is finally placed just anterior to the posterior sucker and close to the body of the *elegans*.

There is then a considerable struggle during which the *dawbini* changes the position of the anterior sucker. Most commonly in this and other trials the struggle terminated with the posterior end of the body of the *dawbini* extending across the posterior portion of the *elegans* ; then lengthwise along the side of the *elegans* and progressively beneath it along the clitellar region ; and the anterior sucker of the *dawbini* attached to the venter of the posterior portion of the preclitellar region of the *elegans*.

In this manner, the anterior sucker of the *elegans* is prevented from reaching the solid surface, and the *elegans* is entirely immobilized. The manner in which the *dawbini* secures the *elegans* is suggestive of a modification and deviation of copulatory behaviour.

In various trials, the pair remained stationary in the one place and in the one posture for ten to twelve hours, and some few longer before separating.

The released *elegans* is not firm bodied. It appears flabby, shrunken, with some regions showing partial collapse, and there are small clouds of coagulated mucus. Leeches in this condition are sluggish in behaviour, swim feebly, survive some few hours, and die. *K. dawbini* were not seen to attack a leech enfeebled in this manner.

Following release of the *elegans*, the crop of the *dawbini* is only partially distended. It contains a thin pale whitish milky fluid rich with many small clear colourless oil droplets. This has been seen also in the crop of *dawbini* taken in the field in March and April.

Rapid attack and sustained attachment are shown also when a large earthworm is supplied to *dawbini*. The *dawbini* becomes immediately restless, commences swimming within 15 seconds, and attaches by the anterior sucker anterior to the clitellum within 45 seconds. The *dawbini* partially wraps around the worm, and attaches the posterior sucker to the jar. The two remain in this manner and without change in position for twelve and a half hours, or even more.

Following attachment of the anterior sucker to the worm, the worm struggles actively for some three minutes. It then slowly extends, becomes quiescent, intestinal peristalsis ceases, and it becomes unresponsive to the touch, with no reaction to stroking or gripping lightly with the forceps, all as though the worm was anaesthetized or in severe shock. An hour later, with the leech still attached, the worm is fully responsive to stimuli, and intestinal peristalsis is normal.

K. dawbini as readily attaches to large grass grubs.

Mass Aggregation of Goddardobdella elegans

Mass aggregations occur with the appearance in the open of a large number of active individuals of a single essentially secretive species of aquatic leech. It is an occasional and temporary event extending over two or three days, with the number of individuals greatly in excess of the normal population of the locality where the aggregation develops. It is associated with upstream mass movement or migration.

A localized population increase occurs with some species in the mating season. The individuals continue to be secretive, and accordingly I have referred to it previously as reproductive swarming since it differs in this way from mass aggregation which is not correlated with reproduction. Dr. M. Howell, the Australian National University, has described to me behaviour by *Vivabdella arcana* similar to reproductive swarming.

Mass aggregation has been reported for some macrophagous haemopids and erpobdellids in North America (Richardson, 1942 ; Sawyer, 1970). Sawyer found aggregation of *Erpobdella punctata* associated with an abundant availability of an aquatic annelid ; but there was no correlation with food supply in mass aggregations which I studied in the Province of Quebec. Mass aggregations of *Percymoorensis marmoratis* were possibly migratory. Aggregation activity could be followed upstream for two or three days with a population of this large leech of five to 10 individuals to a square yard of the bottom. The size of the aggregations diminished after the third day. The late Professor J. Percy Moore wrote me he had seen behaviour of this kind in Himalayan streams.

In the present case, a class of school pupils collected 23 *G. elegans* and four *K. dawbini* from Alumy Creek, Grafton, in a short interval of time on the 10th of November, 1967. A second collection from the same vicinity on the 14th of November contained 133 *elegans* and 36 *dawbini*.

Individuals of *G. elegans* were active and obvious among the sparse rooted aquatic vegetation in the shallow marginal waters to a depth of one foot, with one *elegans* to the square foot.

None were to be seen in this manner in the creek on the 15th of November, or later. The population reduced to about the usual level, i.e. in the order of one individual to 15 to 20 square feet.

Features here common to mass aggregation as known to me previously are : initially, small numbers of *elegans* active in the open ; a sharp rise to peak numbers greatly above the normal population ; a sudden total disappearance of active *elegans* in the open ; with this, a drop to the normal population level ; no correlation with any change in the availability of food.

The mass aggregation was found near the head of the creek, indicating the probability of an upstream migration, as seen in other cases.

The activity of the *K. dawbini* in the open at the time of the mass aggregation can be reasonably correlated with predation on the readily available *G. elegans* ; but the number of *dawbini* favour some measure of upstream movement for this species also.

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References

Blair, W. N., 1927.—Notes on *Hirudo medicinalis*, the medicinal leech, as a British species. *Proc. Zool. Soc. Lond.*, 1927 : 999–1002.

Bosisto, J., 1859.—Art. 3. On the *Hirudo australis*. *Trans. phil. inst. Victoria*, 3 : 18–22.

Keegan, H. L., Toshioka, S., and Susuki, H., 1969.—Blood sucking Asian leeches of families Hirudidae and Haemadipsidae. Spec. Rept. 406th Med. Lab. U.S. Army Medical Command, Japan, 1.vi, 1–130.

Pinto, C., 1923.—Ensaio monographico dos Hyrudineòs. *Rev. Mus. Paulista.*, 13 : 5–266.
Richardson, L. R., 1942.—Observations on the migratory behaviour of leeches. *Can. Field-Naturalist*, 51 : 67–70.
————, 1969*a*.—A contribution to the systematics of the hirudinid leeches with description of new families, genera and species. *Acta Zool. Hung.*, 15 (1–2) : 97–149.
————, 1969*b*.—The rediscovery of *Hirudo elegans* Grube 1867. *Mem. Queensland Mus.*, 15 (3) : 191–203.
————, 1970.—*Bassianobdella victoriae* gen. et sp. nov. (Hirudinoidea : Richardsonianidae). *Mem. natl. Mus. Victoria*, 31 : 41–49.
————, 1971.—*Bassianobdella ingrami* sp. nov. from Tasmania. *Pap. Proc. Roy. Soc. Tasmania*, 106 : 113–118.
————, 1972*a*.—*Bassianobdella fusca* sp. nov. (Hirudinoidea : Richardsonianidae) with an initial demonstration of systematic values in the lengths of annuli in the mid-nephric somites. *Rec. Australian Mus.*, 28 (8) : 129–139.
————, 1972*b*.—*Quantenobdella howensis* Richardson 1969 of Lord Howe Island, with a brief comment on dispersal by passive transport (Hirudinoidea : Richardsonianidae). *Mem. natl. Mus. Victoria*, 33 : 65–72.
————, 1972*c*.—*Habeobdella stagni*, a new genus and species from South Western Australia (Hirudinoidea : Richardsonianidae). *J. Roy. Soc. Western Australia*, 54 (2) : 47–52.
Sawyer, R. T., 1970.—Observations on the natural history and behaviour of *Erpobdella punctata* (Leidy) (Annelida : Hirudinea). *Amer. Midl. Naturalist*, 83 (1) : 65–80.